DOCUMENT RESUME

ED 363 514 SE 053 842

AUTHOR Lloyd, Carol V.
TITLE Social Contexts for Literacy: Two Biology Classrooms.
PUB DATE Apr 93
NOTE 27p.; Paper presented at the Annual Meeting of the American Educational Research Association (Atlanta, GA, April 1993).
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Biology; Case Studies; *Classroom Environment; *Constructivism (Learning); High Schools; Problem Solving; *Science Instruction; Science Teachers; *Scientific Literacy; Secondary School Science

ABSTRACT

There is a growing body of current research that addresses literacy from the perspective of literacy as a social process. This perspective underscores the need to examine the culture of classroom in our attempt to understand how students learn and become literate within a discipline. This paper presents two case studies of high school biology classrooms within this framework. One classroom was taught by a teacher whose articulated beliefs about learning and observed teaching could be describes as constructivist. The classroom culture in his room was one in which students learned about biology through their interaction with each other and the ideas of biology. The reading and writing tasks within this classroom culture contributed to their sense that scientific literacy was about learning ideas and solving problems. The second classroom was taught by a teacher whose articulated beliefs and observed teaching could be described as behavioral. The culture he created in his classroom left students with the sense that scientific literacy was about reading to memorize facts and writing to accumulate pages of information. These findings are related to attempts to improve science teaching in ways that will enhance student learning and literacy in biology.
(Author)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED 363 514

SOCIAL CONTEXTS FOR LITERACY:

TWO BIOLOGY CLASSROOMS

Carol V. Lloyd

Paper presented at the annual meeting of the American Educational Research Association, Atlanta, GA, April, 1993.

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

Carol V. Lloyd

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☒ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

SE 053 842

SOCIAL CONTEXTS FOR LITERACY:
TWO BIOLOGY CLASSROOMS

Author: Carol V. Lloyd

Position: Assistant Professor of Teacher Education

Office Address: University of Nebraska at Omaha
College of Education
Kayser Hall 514
Omaha, NE 68182-0163
(402) 554-3471 FAX: 402-554-3491

E-mail: Internet: CLLOYD@CWIS.UNOMAHA.EDU

This study was sponsored, in part, by the University Committee on Research at the University of Nebraska at Omaha. The opinions expressed in this paper do not necessarily reflect the position, policy or endorsement of the University of Nebraska at Omaha.

Abstract

There is a growing body of current research that addresses literacy from the perspective of literacy as a social process. This perspective underscores the need to examine the culture of classrooms in our attempt to understand how students learn and become literate within a discipline. This paper presents two case studies of high school biology classrooms within this framework. One classroom was taught by a teacher whose articulated beliefs about learning and observed teaching could be described as constructivist. The classroom culture in his room was one in which students learned about biology through their interactions with each other and the ideas of biology. The reading and writing tasks within this classroom culture contributed to their sense that scientific literacy was about learning ideas and solving problems. The second classroom was taught by a teacher whose articulated beliefs and observed teaching could be described as behavioral. The culture he created in his classroom left students with the sense that scientific literacy was about reading to memorize facts and writing to accumulate pages of information. These findings are related to attempts to improve science teaching in ways that will enhance student learning and literacy in biology.

Scientific Literacy in Two High School Biology Classrooms: Considering Literacy as a Social Process

In recent years, researchers concerned with literacy issues have moved from the laboratory to the "real worlds" of the classroom, the home, the community, and the workplace (Bloome, 1987a). Such a shift expands our assumptions about the factors that influence literacy and has generated a view of literacy as a social process. This expanded perspective contextualizes literacy and considers more complex interactions between the learner and the environment than were often possible in laboratory experimentation.

Researchers and theorists who advocate the contextualization of literacy in schools (e.g., Bloome & Green, 1984) examine literacy as social events in classrooms and describe how these complex events are important in understanding student learning. Within this framework, classrooms develop their own culture through the complex interactions of the participants within a particular setting (Bloome, 1987c; Green, 1990).

Bloome (1987c), for example, describes three categories of reading research that are concerned with the social processes of reading. One category considers reading within a social/communicative context. Salient issues in this category include the opportunities to gain access to literacy events and the nature of those opportunities. A second category focuses on the social uses of literacy. Studies within this category are concerned with the interplay between what counts as reading and

writing and the situation. Studies examining reading as a sociocognitive process form the third category. These are concerned with the nature of literacy as "a process of socialization, enculturation, and cognition" (Bloome, 1987c, p. 126).

Little of the work concerned with literacy as a social process has examined the culture of secondary school classrooms. [See Bloome (1987b) for a collection of papers from a conference addressing secondary schools.] With a few notable exceptions (e.g., Lemke, 1990; Tobin, Kahle, & Fraser, 1990), there is a paucity of studies that describe how classrooms influence the development of scientific literacy in secondary science classrooms from this perspective. These understandings are especially important as science education is criticized for the large number of scientifically illiterate students enrolled in and graduating from our schools (Miller, 1989; Mullis & Jenkins, 1988; National Science Foundation & Department of Education, 1980).

Studies describing secondary school classroom practices that address literacy issues inform us that teachers regularly use science textbooks for their curriculum (Gallagher, 1986; Yager, 1983), and that this curriculum typically focuses on the facts of science at the expense of higher-level thinking about real-world issues (Harms & Yager, 1981; Stake & Easley, 1978). We have also learned that students rarely have the opportunity to use writing to synthesize ideas (Applebee, 1981), an unfortunate circumstance

considering the potent effects of writing on thinking (Tierney, Soter, O'Flahavan, & McGinley, 1989).

Studies examining how teachers make decisions about curriculum and teaching practices demonstrate the pervasive impact of teachers' beliefs about their roles, student learning, subject matter, teaching methods, and administration expectations in their day-to-day planning and implementation of lessons (Munby, 1984; Richardson, 1990; Tobin & Espinet, 1989).

The research reported here comes from a larger study of two high school biology classrooms. It adds to the small but growing examinations of the factors that influence literacy in science classrooms from the perspective of social processes. From descriptions of the interrelationships between teaching, learning, teacher beliefs, and student perceptions, the culture of these two classrooms will be described. These cultures provide the framework for understanding how classrooms contribute to students' developing literacy in science.

Method

Research Setting

This study took place in two biology classrooms, each taught by a different teacher, in one Midwestern urban high school with approximately 1100 9th-12th graders. The ethnic composition of the student population was about 70 per cent White, with most of the remaining 30 per cent African American. Of the 77 teachers on the faculty at the time of the study, eight taught science classes; four of these taught biology.

Though two volunteers were requested for the study, the science curriculum specialist and the principal selected the two participants, Larry and Ed. Both had taught biology for several years.

These two teachers taught the same first year biology course and used the same textbook and basic curriculum. This was the first year that these teachers (and this district) had used this textbook. The student populations in these two classrooms differed, however. The students in Larry's class were 10th-12th graders who were either taking their first science class or repeating a failed biology course. In contrast, all of Ed's students were ninth graders. There were approximately equal numbers of girls and boys within and between classes. The ethnic mix in each class represented the general school population.

Research Procedures

Data collection. Because this study examined typical classroom contexts, participant observation was the major research methodology (Spradley, 1980). The author and two research assistants were participant observers in these two classrooms over the same time period in the spring semester. When no new trends or themes emerged (Bogdan & Biklen, 1982), data collection was terminated.

Data was collected in Larry's classroom for 24 consecutive days plus 5 more consecutive days towards the end of the study. Larry's class focused on six major topics during this time period. Data was collected for 32 consecutive days in Ed's

class. His class focused on 11 major topics during this time. The difference in numbers of days of data collection reflected the pacing of each teacher, the decision to begin observations at the beginning of a unit, and the decision to complete the study at the end of a unit.

Three data sources described teachers and students: daily observations, informal interviews about a day's lesson, and structured interviews. These varied sources provided alternative perspectives to the classroom interactions. Data was collected simultaneously on the teacher and students: the author collected data on students while a research assistant collected data on the teacher.

Each research assistant was trained in data collection procedures prior to the study and assigned to one teacher. Each audiotaped teacher talk each day while writing descriptions of teacher behaviors that included brief descriptions of the content of teacher talk. Later, each research assistant combined these two data sources into one transcription for each daily observation.

The author observed two students extensively in Ed's classroom and four in Larry's. The original plan called for observations of two students in each class. However, the types of interactions that occurred in Larry's class made it conducive to observing more students. According to their teachers, the sample students represented both successful and unsuccessful students in each class. The observational data collected on

these students consisted of timed field notes describing their verbal and nonverbal behaviors. Since more than one student was observed in each room, observations alternated between them.

All interviews were conducted by the author. Informal interviews of teachers were conducted periodically during the teacher's preparation time when questions arose about the tasks that were observed that day. These questions asked about the purposes of the tasks, teachers' notions of biology teaching and learning related to the lesson, the rationale and effects of the participatory structures, their sense of students' understandings of ideas, and a particular student's talk or behavior. Other informal interviews occurred when a teacher would spontaneously talk about something that had happened in class that day.

Informal interviews of the sample students occurred whenever students were involved in labs or seatwork. They were typically questioned about their understandings of the task in which they were engaged.

Structured teacher interviews were conducted individually at the completion of the study about their beliefs about teaching, learning, students, and biology. The sample students were formally interviewed about their content knowledge at the end of two units. Additionally, they were interviewed at the end of the project about biology in general, their classroom, and their learning. All interviews were audiotaped and transcribed.

Analysis. Several themes began to emerge during data collection (Bogdan & Biklen, 1982) from teachers' articulated

beliefs about student learning, text, and the relationship between the participatory structure and learning. Themes about students' understandings of ideas and the role of text were also becoming apparent during this time. At the completion of the study, all observation and interview transcripts were read. Using the constant comparative method (Glaser & Strauss, 1967), the themes that had emerged during observations were explicated within the framework of literacy in these classroom cultures. These themes are reflected in the results.

Internal validity of the findings was achieved through the triangulation of data sources and through the recurring patterns across days.

Results

Five major themes were identified that reflect the relationships between the social processes in these classroom and students' developing literacy in biology. These themes are the relationships between 1) teachers' beliefs about teaching, learning science, and the function of the textbook; 2) teachers' beliefs about learning, writing, and the writing tasks in each classroom; 3) the social interactions, assigned tasks, and the definition of learning; 4) what teachers considered as important types of learning and students' accountability for learning; and 5) the influences and beliefs of participants and the culture of each classroom. These five themes emphasize different perspectives of these classrooms to provide a broad description of the classroom cultures in relationship to literacy.

Therefore, the various factors that impact each perspective are not unique to that perspective, and may be found in more than one theme. It is as if one were revisiting the same landscape from different routes (Wittgenstein, 1953).

Relationships between teachers' beliefs about teaching, learning science, and the function of the textbook. Each teacher's beliefs about teaching and about learning science impacted the function of the textbook in these classrooms.

This is an important finding for at least two reasons. First, science teachers have been criticized for their excessive reliance on science textbooks for botn curriculum and instruction (Mayer, 1986). Second, reading researchers have described the effects of the difficulty of materials on the nature of instruction. For example, Barr (1987) describes how a high school English teacher altered instruction when the texts students read became more difficult.

The same textbook was used in both classrooms. It was very difficult, contained a dense concept load and large number of technical vocabulary, and could be characterized as encyclopedic (Blystone, 1987). In both classrooms, it was the only text students were expected to read unless they wanted to write an extra credit report to answer a question.

The textbook in Larry's classroom defined the curriculum. Virtually all classroom tasks were text reproduction (Bloome, 1987c) tasks. Students were expected to read all pages of assigned chapters, Larry's lectures retold each chapter,

students' notes were supposed to summarize the text, and students were given publisher's workbooks on vocabulary and concepts at the end of each chapter. All tests had been written by the publisher, with most questions asking for further restatements of the text-based ideas and vocabulary. Though this description of how Larry used the textbook exemplifies those classrooms which have been criticized by science education researchers, it is important to understand why this occurs if effective changes can be made.

Larry talked about the complexity of the book and how he deleted some test questions he thought were "too picky." He also described omitting chapters because he could not cover all the content in one year. In addition, he also thought he was addressing the difficulty of learning from this complex text by asking students to take notes and complete workbook pages.

In Ed's class, the book was both a topical guide and a reference book. Like Larry, Ed also recognized the dense concept and vocabulary load in this book. He omitted many ideas and technical vocabulary because of this density and because he did not think that many of these ideas were important for high school students to know. He thought that students interested in them would continue their biology education in college. Before an exam, Ed told the students which sections of the relevant chapter had information they needed to know.

In Ed's class, the ideas in the textbook were woven into the classroom discussions and labs. In a typical lesson, the

information in the textbook was used to introduce a topic, was referred to periodically during discussions, and was a reference as students completed laboratories.

Relationships between teachers' beliefs about learning, writing, and the writing tasks in each classroom. Teachers' beliefs about the relationships between learning and writing affected the types of writing tasks students were assigned.

The students in Larry's class were required to do the kinds of writing that have been described by Applebee (1981) as typical of secondary classroom writing tasks, namely fill-in and short answer as students completed workbook pages and answered questions about labs. Longer discourse consisted of some type of textbook restatement and notes copied from the board. Students rarely had writing tasks that required them to synthesize ideas. One student, knowing that the volume of textbook notes was important, began to copy the textbook into his notebook.

The writing assignments Larry made corresponded to his beliefs about such activities. He believed that these various writing tasks would help students learn through repeated encounters with the ideas. He never spoke about students' interactions with ideas.

There were two major types of writing tasks in Ed's class: taking notes during discussion and writing lab reports. The lab reports required students to integrate their lab results with textbook facts, and to integrate their results with their hypotheses in a summary section. Ed's beliefs about writing are

exemplified in an informal interview in which he expressed a concern that students did not seem to understand that he wanted a synthesis of ideas in their lab summaries. In fact, the day after he expressed this frustration, he talked about summary writing to his class.

Relationships between the social interactions, assigned tasks, and learning. The nature of the social interactions between participants as well as the types of tasks in each classroom defined the nature of learning.

In Larry's class, learning was defined as the ability to give correct answers during recitation, reproduce textbook ideas in a notebook, and get the correct answers on written work. Larry did not think that students could learn well while working together and was uncomfortable when students worked with partners during labs, believing that students would divide the tasks and only learn the parts they had completed. Since the labs Larry assigned typically required students to follow a procedure and answer literal level questions, the types of interactions between students focused on completing the next step in a lab and finding an answer to write down. He did not think about the possibility of altering the tasks so that interactions between students would actually enhance learning.

In Ed's class, learning was defined by students' interactions with and construction of ideas. This was apparent when Ed encouraged students to bring their experiences and questions into discussions. Though he used materials from the

text to begin a lesson, Ed had worked for many weeks at the beginning of the year to encourage students to talk about their related experiences and to ask questions about the ideas. Ed's definition of learning was also apparent during labs. There were at least two factors during the labs which affected the learning environment. One was number of lab-related tasks that required students to go beyond surface level ideas. The second factor was the general climate Ed had cultivated in his class that encouraged students to share ideas. During labs, these types of interactions were extended so that students within and between lab groups helped each other solve problems, answer questions, and correctly execute procedures.

The relationships between what teachers considered as important types of learning and students' accountability for learning. There was a consistency in Larry's class between what was considered important types of learning and the ways in which students were held accountable for that knowledge; in Ed's class, there was some contradiction between these two constructs.

In Larry's class, success (i.e., grades) was measured by students' scores on vocabulary workbook pages, numbers of pages of notes taken, and scores on tests. The test questions, written by the textbook publisher, were predominantly multiple choice, with a few short answer questions.

Ed subjectively assessed students' daily success through their participation in whole class and small group discussions. However, this participation was not measured or factored into

grades. Rather, grades were determined from students' lab reports and exams. The labs had several questions that required higher level thinking and synthesis of ideas. This part of the students' grade matched what appeared to be valued in this classroom, namely higher-order cognitive processes such as analysis and synthesis. The exams focused on factual information that was based on explicitly stated information in their textbook. Though Ed developed his exams, wrote fill-in and a few short-answer questions, and asked students about less information than Larry, the tests from each teacher were similar in their focus on the detail of the content. This component of student assessment seemed inconsistent with Ed's beliefs about learning.

The relationships between the influences and beliefs of the participants and the culture of each classroom. The culture of each classroom resulted from the influence and beliefs of the participants.

Larry's class was dominated by the teacher. Though he talked about being concerned about the students both as individuals and as learners (and most likely was), his actions as a teacher rarely displayed these considerations. Most tasks were centered around the content, rather than around students' understandings, questions, or purposes. During observations, students displayed a lot of passive resistance by writing notes to one another, putting their heads down on their desks, and writing their textbook notes during lecture time. When students were interviewed about the tasks they were doing, several

spontaneously talked about how they wanted the participation structure altered in ways that would allow them to work together more often and therefore learn better.

Ed's class represented a very different culture. Sharing ideas, control of content, and procedural knowledge were characteristic of most of the classes that were observed. However, Ed developed and maintained the role of content expert when students asked questions. Otherwise, this class displayed many instances of both teacher and students providing scaffolding for student learning (Vygotsky, 1978).

Discussion

This study provides examples and support of how literacy is a sociocognitive process and how school-based literacy must be examined within the complex context of classrooms. When teachers overemphasize the text as Larry did, literacy and learning are reduced to memorizing vocabulary and facts. Larry's view of learning generated teaching practices that led to student behaviors and perceptions that are antithetical to literacy, namely boredom, lack of attentiveness, disinterest in reading about science, and a sense that science rarely has personal significance. In contrast, when literacy and learning are viewed as expansive, reading and writing become part of meaningful learning experiences. Ed's expansive and constructivist view of learning generated teaching practices which lead to student behaviors and perceptions that contributed to a deeper literacy. These students were actively involved in solving problems,

reading and writing to learn, and connecting the ideas of science with their personal histories and futures.

Interestingly, neither Larry's nor Ed's teaching helped the unsuccessful target students improve their grades. However, if being involved in the process of science is also considered as an important outcome of science education (American Association for the Advancement of Science, 1989), then these students in Ed's class had an advantage.

This study casts doubt on approaches to improve biology education that do not address the complex cultures of classrooms. For example, since teachers were known to use textbooks so pervasively, Biological Sciences Curriculum Study (BSCS) was developed to give teachers a "good" textbook to follow. This solution, however, did not meet its intended expectations (Mayer, 1986). Though the development of this curriculum was extensive, it was simplistic in its assumption that altering one facet of instruction, namely the textbook, would be adequate to change teacher behavior and student learning. Effective teacher change must consider more than a change in curriculum, textbooks, or methodology.

What emerges strongly from this study is the power of teachers' beliefs about teaching, students, and their subject area. Teachers have developed integral systems of thinking about what they do, and these ways of thinking impact teachers' practices in their classrooms (Richardson, Anders, Tidwell, & Lloyd, 1991). Ed and Larry provide emphatic yet contrasting

examples of this construct. Ed's articulated beliefs about learning and his observed teaching practices were constructivist (Pines & West, 1986), and the ways in which he talked about his teaching portrayed him as reflective (Schon, 1983). Larry's beliefs and practices were consistent with behavioral theory (Skinner, 1974). At the completion of this project, the principal indicated that he hoped Larry's participation in the research project would motivate him to change, citing the high failure rate of his students. Though one might ascribe Larry's teaching behaviors to typical teacher beliefs that low ability students need instruction that is low-level and repetitive (Allington & McGill-Franzen, 1989), the principal stated that Larry had consistently taught all of his classes in a similar manner. One might wonder if Larry would have been a different kind of teacher if he had experienced, as Richardson (1990) has suggested for all teachers, opportunities to verbalize his beliefs, examine them, and consider them within the context of his classroom and perhaps research.

The results of study also address the issue of access to literacy opportunities, an important issue since equal access to science education is a critical concern of both education and the nation at large (Clewell, Anderson, & Thorpe, 1992). From the obvious differences between these two classroom contexts, students in each class were gaining access to very different types of literacies. But further, students' opportunities to continue their science education in high school and possibly

college were different in these two classrooms by virtue of their grade level when placed in a beginning science course. A focus on literacy as a sociocognitive process might guide teachers in their development and teaching of curriculum, and teachers and counselors in their guidance of students into classes.

Finally, although Ed's class was less dominated by the textbook than Larry's, it played an important role in both classes. Reading in content area classrooms has been criticized for its absence of real world reading tasks. For example, Smith and Feathers (1987) found that reading in high school social studies classrooms centered on acquiring knowledge from the textbook rather than on reading for a meaningful purpose that would reflect how people outside of school actually read social studies type materials. In both Larry's and Ed's classrooms, the textbook was the only text students were expected to read. The only resemblance to "real world" reading tasks occurred when students were engaged in laboratory work and had a question that required some reference material. However, the only questions students were concerned about answering were those posed by the lab directions. When students in either class posed questions that were not answered in their textbook and could not be answered by their teacher, they were directed to do an extra credit report.

The concern about scientific literacy has gained attention in recent years as research has demonstrated that students have not only failed to learn much science (National Assessment of

Educational Progress, 1978; National Science Foundation & Department of Education, 1980) but also that the level of science achievement has actually shown a downward trend (Anderson & Smith, 1986). A need to address this concern has been articulated as one of the goals of America 2000, namely that the students in the United States will attain the highest achievement in science and mathematics than any other students in the world (U.S. Department of Education, 1991).

The development of scientific literacy is a complex process that is guided by the interactions occurring in classrooms. It is these interactions between teachers, students and content that define the culture of a classroom. The forces impacting this culture need to be understood in their relationship to students' developing scientific literacy if improvement in this type of literacy is to be accomplished.

References

Allington, R.L., & McGill-Franzen, A. (1989). School response to reading failure: Chapter 1 and special education students in grades 2, 4, & 8. Elementary School Journal, 89, 529-542.

American Association for the Advancement of Science (1989). Project 2061: Science for all Americans. Washington, DC: American Association for the Advancement of Science.

Anderson, C.W., & Smith, E.L. (1986). Teaching science, Research Series No. 168. East Lansing, MI: Institute for Research on Teaching, Michigan State University.

Applebee, A.N. (1981). Writing in the secondary school: English and the content areas. Urbana, IL: National Council of Teachers of English.

Barr, R. (1987). Classroom interaction and curricular content. In D. Bloome (Ed.), Literacy and schooling (pp. 150-168). Norwood, NJ: Ablex.

Bloome, D. (1987a). Introduction. In D. Bloome (Ed.), Literacy and schooling (pp. xiii-xxiii). Norwood, NJ: Ablex.

Bloome, D. (1987b) (Ed.). Literacy and schooling. Norwood, NJ: Ablex.

Bloome, D. (1987c). Reading as a social process in a middle school classroom. In D. Bloome (Ed.), Literacy and schooling (pp. 123-149). Norwood, NJ: Ablex.

Bloome, D, & Green, J. (1984). Directions in the sociolinguistic study of reading. In P. D. Pearson (Ed.),

Handbook of reading research. New York: Longman.

Blystone, R.V. (1987). College introductory biology textbooks. The American Biology Teacher, 49, 418-425.

Bogdan, R.C., & Biklen, S.K. (1982). Qualitative research for education: An introduction to theory and methods. Boston: Allyn & Bacon.

Clewell, B.C., Anderson, B.T., & Thorpe, M.E. (1992). Breaking the barriers: Helping female and minority students succeed in mathematics and science. San Francisco: Jossey-Bass.

Gallagher, J.J. (1986). A study of secondary science teaching practices. Paper presented at the 59th Annual Meeting of the National Association for Research in Science Teaching, San Francisco (ED 279 525).

Glaser, B., & Strauss, A. (1967). The discovery of grounded theory: Strategies for qualitative research. Chicago: Aldine.

Green, J. (1990). Reading is a social process. In J. Howell, A. McNamara, & M. Clough (Eds.), Social Context of Literacy. Canberra, Australia: ACT Department of Education.

Harms, N.C., & Yager, R.E. (1981). What research says to the science teacher. Washington, D.C.: National Science Teachers Association.

Lemke, J.L. (1990). Talking science: Language, learning and values. Norwood, NJ: Ablex.

Mayer, W.V. (1986). Biology education in the United States during the twentieth century. The Quarterly Review of Biology, 61,

481-507.

Miller, J.D. (1989). Scientific literacy. Paper presented to the 1989 Annual Meeting of the American Association for the Advancement of Science, San Francisco, CA.

Mullis, I.V.S., & Jenkins, L.B. (1988). The science report card: Elements of risk and recovery. Princeton, NJ: Educational Testing Service.

Munby, H. (1984). A qualitative approach to the study of teachers' beliefs. Journal of Research in Science Teaching, 21, 27-38.

National Assessment of Educational Progress (1978). Three national assessments of science: Changes in achievement, 1967-77 (Report #08-S-00). Denver: Education Commission of the States.

National Science Foundation & Department of Education (1980). Science and engineering for 1980's and beyond. Washington, DC: U.S. Government Printing Office.

Pines, A.L., & West, L.H.T. (1986). Conceptual understanding and science learning: An interpretation of research within a sources-of-knowledge framework. Science Education, 70, 583-604.

Richardson, V. (1990). Significant and worthwhile change in teaching practice. Educational Researcher, 19, 10-18.

Richardson, V., Anders, P., Tidwell, D., & Lloyd, C. (1991). The relationship between teachers' beliefs and practices in reading comprehension instruction. American Educational

Research Journal, 28, 559-586.

Schon, D. (1983). The reflective practitioner. New York: Basic Books.

Skinner, B.F. (1974). About behaviorism. New York: Vintage Books.

Smith, K.M., & Feathers, F.R. (1987). Meeting the reading demands of the real world: Literacy based content instruction. Journal of Reading, 30, 506-511.

Spradley, J.P. (1980). Participant observation. New York: Holt, Rinehart and Winston.

Stake, R.E., & Easley, J.A. (1978). Case studies in science education. Urbana: Center for Instructional Research and Curriculum Evaluation, University of Illinois.

Tierney, R. J., Soter, A., O'Flahavan, J. F., McGinley, W. (1989). The effects of reading and writing upon thinking critically. Reading Research Quarterly, 24, 134-173.

Tobin, K., & Espinet, M. (1989). Impediments to change: An application of coaching in high school science. Journal of Research in Science Teaching, 26, 105-120.

Tobin, K., Kahle, J.B., & Fraser, B.J. (1990). Windows into science classrooms: Problems associated with higher-level cognitive learning. London: The Falmer Press.

United States Department of Education (1991). America 2000: An education strategy. Washington, D.C.: U.S. Department of Education.

Vygotsky, L.S. (1978). Mind in society. Cambridge, MA: Harvard

University Press.

Wittgenstein, L. (1953). Philosophical investigations. New York: Macmillan.

Yager, R.E. (1983). The importance of terminology in teaching K-12 science. Journal of Research in Science Teaching, 20, 577-588.